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Author(s): Dave, Bhargav & Pikas, Ergo & Kerosuo, Hannele & Mäki, Tarja

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ViBR – Conceptualising a Virtual Big Room Through the Framework of People, Processes, and Technology

Bhargav Dave^{a,*}, Ergo Pikas^b, Hannele Kerosuo^b, Tarja Mäki^b

^a*Aalto University, Dept. of Civil and Structural Engineering, Espoo, 00076, Finland*

^b*CRADLE, University of Helsinki, Address, Helsinki, 00014, Finland*

Abstract

The “Big Room” in construction refers to a large facility supporting the colocation of the entire project team, where some of the critical problems such as delays in decision-making, problems in communication, disparity in design iterations are eliminated, and trust is increased. However, one of the most demanding aspects of this concept is the almost constant presence of the project participants, which may be difficult for small or medium projects. We therefore propose “Virtual Big Room”, where the concept of collocation of workers will be deployed through virtual technologies. A combination of product and process modelling techniques along with communication and social network tools are proposed to develop the proposed platform that will integrate the entire supply chain through the project lifecycle (i.e. design, construction, handover).

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1. Introduction

Many issues and problems related to construction industry have been published by numerous authors (Egan 1998; Kalamees et al. 2012; Koskela 1992; Kõiv et al. 2014; Winch 2010). In turn, many solutions for these problems have been proposed, and one of these is relational contracting. One type of relational contracting is called Integrated Project Delivery (IPD) (Thomsen et al. 2010). IPD breaks organisational boundaries by aligning the objectives of primary partners through common incentive structures and enables the environment for learning, better

* Corresponding author. Tel.: +358+504-364717; fax: +0-000-000-0000 .

E-mail address: bhargav.dave@aalto.fi

collaboration, and building-up trust. Collaborative contracts using the Integrated Project Delivery (IPD) and Alliancing models have demonstrated significant benefits over traditional projects (El Asmar et al., 2013; Kent and Becerik-Gerber, 2010). It is also well documented that these new project delivery mechanisms rely heavily on lean design and delivery processes and Building Information Modelling (BIM) tools (Eastman, 2011; Porwal and Hewage, 2013).

Within IPD projects, the Big Room concept as an environment has been used to facilitate the deployment of processes and technologies in order to achieve better quality for the client. The Big Room framework has been proven to improve trust, collaboration and communication amongst stakeholders (Bushnell et al., 2013; Raisbeck et al., 2010). However, today's practice of using "Big Room" has some challenges. It demands almost the constant presence of the project participants and therefore renders it impossible to be used on small projects. This means that all the stakeholders have to allocate full time resources to the project in order for the "big room" to be successful. This may be possible for large projects where the budget of the project for individual stakeholders may justify allocation of full time resources, but not for medium or small projects where employees are working on several projects at once, which may be at geographically disparate locations. Thirdly, manual practices and uniqueness of projects and organizations are limiting the potentials of doing knowledge management (Dave and Koskela, 2009). That means, it is very expensive and challenging to externalize lessons learned and standardize developed processes and methods for future projects.

We therefore propose ViBR, where the concept of collocation of workers will be devised through novel information and communication technologies. It is a new concept combining product and process modelling techniques along with communication and social network tools, which together form a platform that will facilitate collaboration between the supply chain throughout the project lifecycle.

The paper begins with a state-of-the-art review of current approaches to collaboration, and follows on to outline the major components of the ViBR concept. The following section outlines the approach called knotworking that will provide a framework for distributed social collaboration. In the next section an encapsulating conceptual framework is provided and the solution explained followed by discussion and conclusion.

2. Current Approaches to Collaboration

A number of underlying processes, tools and technologies are fundamental to the success of a lean and BIM project, as has been demonstrated by some of the completed projects (Dave et al., 2013; Eastman, 2011). Although their composition varies from project to project, Lean Construction and Building Information Modelling can be considered as two main components that support Big Room environment. Specific tools such as i) Set-based design; ii) Last Planner; iii) Design Structure Matrix; iv) Target Value Design; v) Choosing by Advantages; vi) Value Stream Mapping; and vi) Visual Management are most commonly used Lean Construction tools and i) Visualisation, clash detection, 4D simulation; ii) 5D modelling (quantity and cost); and iii) Model based prefabrication are most commonly used BIM tools.

Within this article, we focus on how these technologies (in its wider sense) could be used within "Big Room" digital environment. The "Big Room" as mentioned above refers to an environment that supports the collocation of project teams and is used across the whole project lifecycle. Through collocation, some of the critical problems such as delays in decision-making, problems in communication (due to unavailability or other reasons), disparity in design iterations, etc. are eliminated (Dave et al., 2013). On the other hand one of the crucial elements for project success, i.e. trust between stakeholders is significantly improved as they work together on almost daily basis, as if they are working for the same organisation overcoming cross-organisational boundaries. Figure 1 shows an example of a Big Room at Sutter Health's Eden Medical centre project in California, USA.



Figure 1 - Big Room at Sutter Health's Eden Medical Project (Image Courtesy, Sutter Health USA)

3. Main Components of the Virtual Big Room

Figure 2 - ViBr Platform

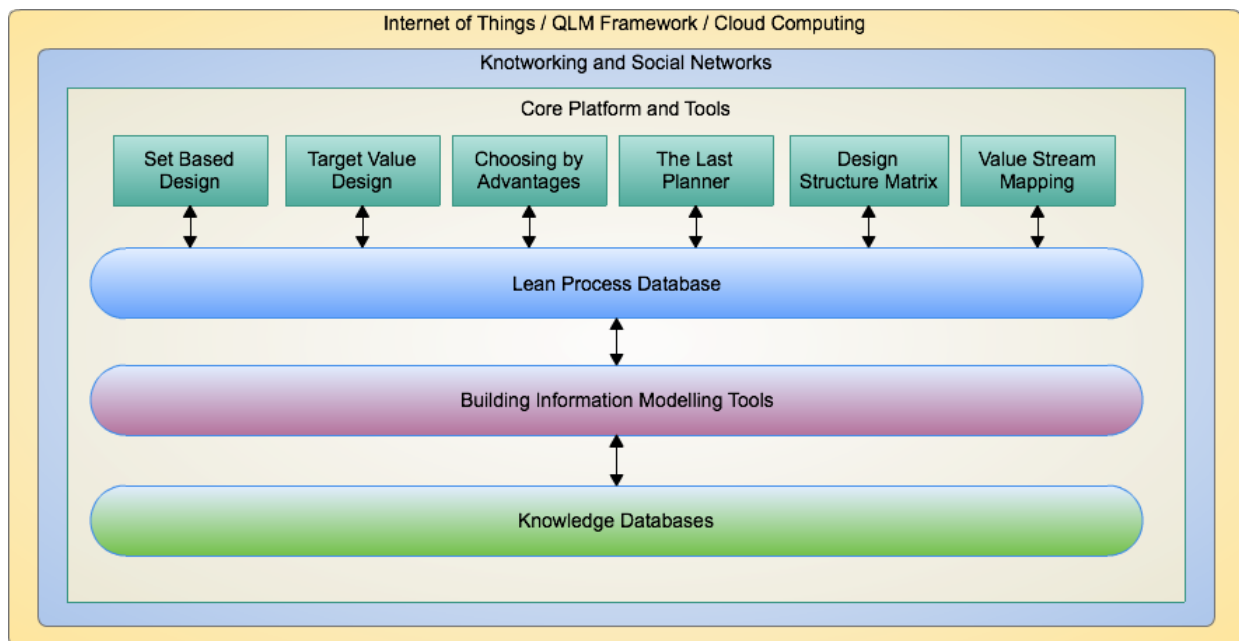


Figure 2 outlines major components of the ViBR platform. At the heart of the system are Lean Processes and Tools along with Building Information Modelling tools and systems. These systems help manage both the product and process management. The knowledge-based tools will combine Internet of Things concepts and communication tools that will help gather knowledge about design objects, systems and components through the lifecycle. For example, a building element such as a door will have a URI (Unique Resource Indicator) through which information

such as cost, past performance (in various conditions) including user ratings, and design specifications would be available at the design phase through BIM tools. The same URI will enable information retrieval and input during the lifecycle of the door, ensuring knowledge capture and reuse. The middle layer of social networking tools and knotworking will provide people oriented tools to promote collaboration and improving trust and communication through the lifecycle of the project. Further information about knotworking is provided in Section 4.

Lean Construction since it's beginning has become an effective approach to solve many of construction industry's problems. It provides a strong theoretical platform in the form of "TFV" (Transformation, Flow and Value) theory (Koskela 2000) along with a host of practical tools, which are now being applied on construction projects worldwide (Ballard 2000; Zimina et al. 2012). Some of these lean tools and underlying processes play a key role in the "Big Room" setting. A selection of the important tools is listed below and will be included in the development of new interfaces for the ViBR. Table 1 provides an overview of these tools in the ViBR context.

Table 1 - Lean and BIM tools in ViBR context

Tool	Description	ViBR Context
Dependency Structure Matrix	DSM was developed by Steward (1981) to improve the efficiency of problem solving. It is an analytical reductionist approach for decomposing problems into simpler ones and defining their dependencies. By knowing the latter, we can start to look for optimal sequences of problems.. Huovila et al. (1997) used DSM for building design problems. Choo et al. (2004) intended to use DSM together with Last Planner System within a software for enabling design management.	In ViBR, DSM will be used in conjunction with the Last Planner system and Knotworking to identify key design iteration cycles and handover points to ensure that collaboration is effective within the team.
Choosing by Advantages	CBA comprises set of methods for making decisions, from very simple to extremely complex (Suhr, 1999). The underlying assumption is that making a decision is a process and includes several steps to draw inferences. The objective is to enable project partners to make sound decisions in a more holistic way. Arroyo and Ballard (2014) studied multi-criteria decision making methods and concluded that CBA method compared to the analytical hierarchy process (AHP) is preferable in construction decision making. For detailed information on CBA use in construction, see (Parrish 2009).	The CBA system presents several phases, ranging from the stage-setting phase, an innovation stage, the decision making phase and the implementation phase. In ViBR the first two phases will be enable by providing BIM based interfaces, while the third phase will be enabled through a collaborative discussion process.
Target Value Design	Target value design (TVD) is a lean construction management approach (Zimina et al. 2012) to systematically design for client value by meeting minimum project constraints (Ballard, 2008). It is a method that combines the target costing with lean construction principles. Typically, one of the constraints is budget constraint set by the client (maximum availability of funds) that the project must meet.	In TVD, the team sets aggressive targets and constantly tracks the current design sets against the budget. This information is visualised through charts on the walls. In ViBR, computer based tools integrated with BIM will provide cost estimate as the design develops. Figure 3 shows how the TVD charts in the virtual environment will be displayed.
Value Stream Mapping	VSM is a visual tool for documenting and visualizing all the steps in the workflow that add value to the final deliverable from the perspective of the customer (Rother and Shook 2003). The team discuss, as they create the map, their understanding of the design, their own work, and how their work connects to the work of others on the team. The team negotiates what they need to produce and at what level of detail so that downstream work can proceed with more certainty, and eliminate non-value adding tasks.	VSM will be applied in both physical and virtual forms and synchronised to make it available to the project team for reference. In ViBR, virtual Post It note type interfaces for task representation and management will support the deployment of the VSM process.
The Last Planner	The LPS (Ballard 2000) was devised for the purpose of achieving reliable and stable workflows. Typically, work is performed at the end of a chain of decisions made by the people involved in the planning of the work at increasingly detailed levels of resolution. Originally, LPS stages were defined as master planning, phase planning, look-ahead scheduling and weekly work planning (Ballard 2000). Initial evidences show that LPS could be used also for design (Hamzeh et al. 2009).	The LPS type collaborative planning process in conjunction with the Knotworking approach will support collaborative planning, scheduling, execution and review processes in ViBR. They will be further supported by field based computer tools for near-real-time synchronisation of task statuses (Dave et al., 2014).
Technologies	We anticipate a host of technologies to play a key role in enabling the virtual big room. The technologies range from BIM platforms, which play a central role in providing a product and process modelling, visualisation and communication platform, to communication technologies based on the Internet of Things (IoT) standards, along with information visualisation, social collaboration and knowledge management platforms. Combined, these technologies will virtually support the entire lifecycle of conceptual design, detailed design, construction and handover through a virtual co-location space.	

Tool	Description	ViBR Context
BIM	BIM is defined by the authors of the 'BIM Handbook' (Eastman et al. 2011) as a verb or adjective phrase to describe tools, processes and technologies that are facilitated by digital, machine-readable documentation about a building and its performance, design, construction, and operation. With their highly visual and information rich models, they have surpassed their role as just the product modelling platform and are also supporting new business processes, and more importantly are proven to support lean deployment (Sacks et al. 2010).	BIM plays a key role in current Big Room deployment as the designers and other stakeholders synchronise and visualise the design as it progresses, eliminating the need for communicating with 2D drawings and improving the quality of design. In ViBR, a set of new tools and processes will be developed to support such direct communication between stakeholders through virtual platforms, where the designers may be located in geographically disparate locations.
Internet of Things and cloud computing	One of the fundamental building blocks of efficient project delivery is effective communication. The traditional Big Rooms enable direct communication by hosting most of the project team members in the same room. This way, the need for RFIs (Request for Information), which have been identified as a root cause for time overruns and cost escalation as in traditional projects is almost eliminated.	Providing effective communication channels in the Virtual Big Room is of utmost importance and will be achieved by the new Internet of Things based communication channels such as Quantum Lifecycle Messaging (Dave et al., 2014). Also, the communication technologies will be tightly coupled with the social networking and knowledge management platforms, where combined they will provide the fabric for collaboration in the new virtual environment.
Social Networking and Knowledge Management	On construction projects, collaboration and trust play a crucial role in effective delivery and smooth production at all stages. The traditional Big Room enables this by collocating the project partners in the same space, hence through face-to-face informal communication and creation of a virtual organisation. This way, the participants openly share their knowledge with each other and can communicate freely without organisational boundaries as compared to traditional construction projects. Here, one of the important enabling aspect is also the kind of partnering project (such as IPD or Alliancing), which provide common project based incentives for each organisation.	In the proposed platform, most of the enabling technologies and data will be hosted through cloud platforms to enable distributed delivery of services. The challenge for the virtual Big Room is to provide such a highly collaborative environment, where mutual trust can be built and open sharing culture can be supported. Some of the new social networking tools provide an ideal platform to provide such a collaborative environment and have proven to be effective in knowledge sharing within distributed teams. The proposed system will utilise such tools along with appropriate communication technologies to build such a social platform.
Information Visualisation	In traditional Big Rooms, project related information is displayed on the walls to enable efficient visualisation of information for project members. Key information and metrics such as Target Value Design parameters, Percentage Plan Complete, Value Stream Maps, A3s and project plans (at various levels) are commonly displayed on the walls. The proposed platform will create virtual environments where participants will be shown relevant project related information in a visual way.	Information visualisation will be achieved through a variety of tools and interfaces. Figure 3 shows how various charts will be constantly displayed and will mimic the physical Big Room environment. Also, through an “intelligent wall”, participants will be able to use any lean or BIM in a collaborative way, in both the virtual as well as the physical environment.

4. Aligning People and Processes – The Knotworking Approach

The idea of knotworking was introduced as a new social form of collaborating across disciplinary boundaries in building projects. Construction processes involve phases and tasks that cannot be solved in one organization only, as integration of expert knowledge from various sources is needed. Through knotworking, groups of people, tasks and tools are set to work intensively for a short period of time to solve a problem or accomplish a task, either virtually or co-located (Kerosuo, Mäki & Korpela 2013). The practice of knotworking has been developed and applied in the development of healthcare organizations, libraries and school-university relationships, and has been recently applied also in the construction industry in RYM-SHOK PRE-program (<http://rym.fi/knotworking-boosts-decision-making-and-productivity/>). A ‘knot’ represents a distributed collaborative expertise in pursuit of a common task in a design process. Knots are characterized by a movement of being tied, un-tied and re-tied depending on the object of activity (Engeström 2008, 194). The object of activity is here understood in its activity-theoretical meaning (Engeström 2008: 88-89) as a purposeful, shared target of the designers’ actions and interactions in the design activity. In the development of ViBr, knotworking can be applied in two meanings as a part of the ViBr concept for network collaboration and as a process or a method during which the participants develop the ViBr concept..

5. The ViBR concept

For ViBR concept, we need to align people and processes with technology. However, we can not underestimate the importance of motivated and persistent people and their social needs as they are the essential building blocks of good quality processes (Dave et al., 2008; Koskela and Kazi, 2003). Therefore, one of the aims of this concept is to develop a prescriptive and adaptive framework for aligning people into overall and sub-processes. Prescriptive in a sense, how to model not only product, but also processes and tools for given projects as there cannot be one universal model/template for solving all kinds of projects. This means, that ViBR must enable prescriptive framework for first designing project's processes and tools, together with defining the value objectives, and then enable modelling the product and its content. For example, project team can decide which tools from LPS they use or not, which factors they include in CBA decision making or not. In addition, ViBR concept developed must enable project teams to work interactively or physically or interactively and physically at the same time. The latter is important as well as some people in the team might prefer or can meet face to face, while others can connect only over the world wide web. Figure 3 demonstrates a conceptual representation of the ViBR environment where individual groups and users are represented in their respective clusters, mimicking a physical Big Room environment. Following scenarios outline the functionality of concept in further detail.

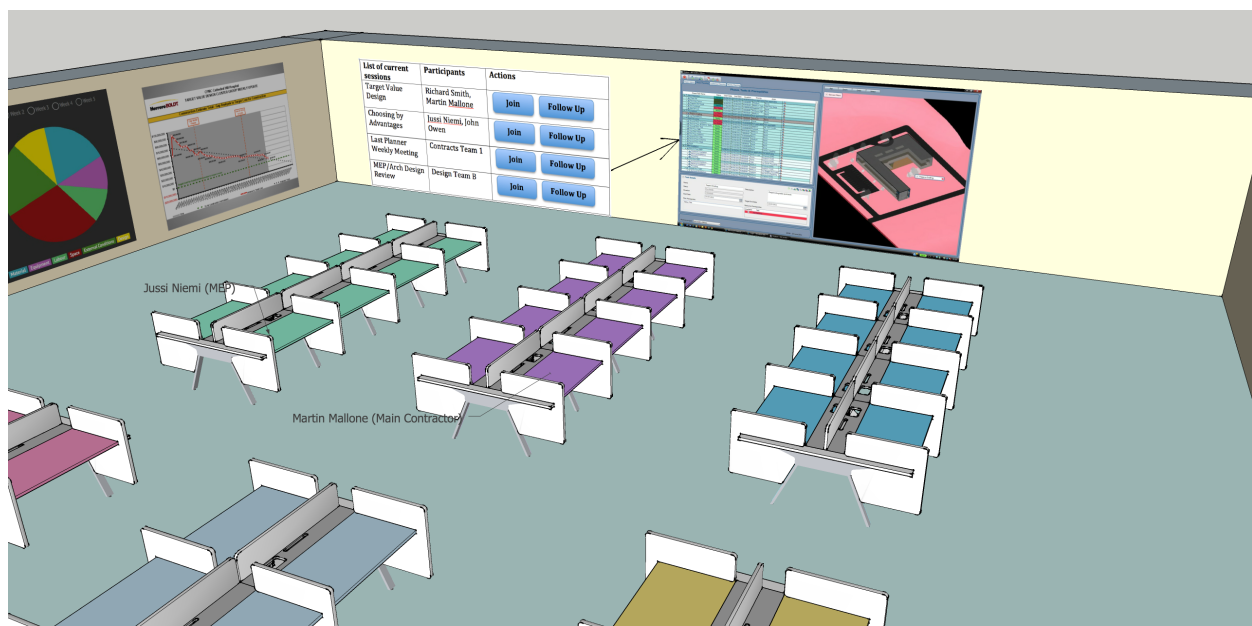


Figure 3 Potential Configuration of a Big Room

Table 2 - ViBR Scenarios

Scenario 1 – General Functionality	Scenario 2 Collaborative BIM Visualisation	Scenario 3 - Choosing by Advantages
The general layout of the solution will mimic that of the actual Big Room, and if there is a physical big room present at the site, it will mirror that. Each cluster, i.e. architects, engineers, main contractor, will be presented virtually. Users will click on another user's avatar and communicate with them directly or get other relevant details such as what aspect of the design	In case two or more users wish to organise a session to visualise the model, they would be offered a selection of current models and will select either single or multiple models to view. The system would work with native modelling software and provide the same functionalities that the native application would provide, however in a	The knowledge-based system would help the designers to identify important factors for selecting a particular product. For example, for a type of a door these could be acoustic isolation, thermal isolation, cost, durability, design aesthetic, etc. The team will also have access to the performance data from past projects and real-time cost data from a web-service based market place connected to the BIM platform. The system would provide a score

they are currently working on. The ViBR environment will also provide interfaces for users to collaborate with each other in real-time using intelligent knowledge-based tools providing an interface for Lean and BIM tools mentioned above.	collaborative manner. Here, the users who are joining from the site based Big Room, will have the model projected in the conference room, using a suitable display medium (i.e. a projector or a large screen display).	for a selection of products and display them side by side. The project team along with client/end users will evaluate and discuss the score and select the product by reaching consensus.
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5. Discussion and Conclusion

Collaborative contracting techniques and the Big Room play a central role in successful delivery of many modern projects. The role of Lean Construction tools and Building Information Models has also been proven to be central in realizing the success of the IPD projects. The proposed concept tries to overcome two specific challenges in this context. Firstly, it attempts to provide systematic and standardized knowledge based tools to support the lean design and construction processes, and secondly it aims to support virtual deployment of such tools for both on-site and off-site collaboration between the construction team. The aspect of virtual teams is not entirely new as they have been discussed since the early 1990s, however, maturing technology, software tools and greater awareness of people and process issues make its deployment more realistic today. It is anticipated that the major benefits of the proposed system would be i) Eliminating the need to relocate key members of staff; ii) Enabling such a successful way of project execution on medium and small projects (comprising a majority share as opposed to large projects); iii) Enabling effective knowledge sharing mechanisms that enable cross project knowledge transfer; iv) Developing new business models to support effective project delivery. It should be noted that this is a very early conceptualisation of the proposed framework and in coming months, the concept will be further refined and some early prototypes will be developed.

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